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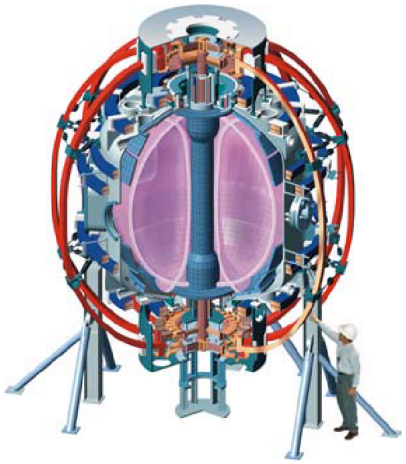

Status and Plans for Boundary and Edge Physics Experiments on NSTX

H. W. Kugel

Plasma Facing Components Meeting
December 06-08, 2004
Livermore, CA

Columbia U
Comp-X
General Atomics
INEL
Johns Hopkins U
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KBSI
KAIST
ENEA, Frascati
CEA, Cadarache
IPP, Jülich
IPP, Garching
U Quebec

PPPL PRINCETON PLASMA PHYSICS LABORATORY

Outline

- Summary of FYO4 Boundary and Edge Experiments
  - Initial Lithium Pellet Injection test
- Proposed FY05 Boundary and Edge Program
  - Proposed FY05 Experiments
  - Off-line Development for Lithium Module-A
  - Possible testing of Lithium Module-A on NSTX
- FY06 Operate Lithium Module-A with graphite PFCs

Summary of NSTX FYO4 Boundary and Edge Experiments

- ST Boundary and Edge Characterization
  - Characterization of Turbulence in the NSTX Boundary (J.Boedo, K.C.Lee)
  - Edge turbulence Studies(N. Crocker)
  - Progress on Characterization of Power Accountability (S.Paul, R.Maingi)
  - Edge Magnetic Probe Measurements for Non Inductive Startup (J.Menard)
  - Initial Comparison of C-MOD and NSTX Edge Rotation (T.Biewer)
  - Gas Puff Imaging Experiments (S.Zweben, R.Maqueda)
  - Impurity Flow, Turbulence, and Behavior of the Edge (C.Bush)
  - Deposition Measurements(C.Skinner)
- Divertor Characterization
  - Initial Characterization of Divertor Regimes(V.Soukhanovskii)
  - Hiroshima Fast Camera Measurements of Characteristic Divertor X-point and Inner Midplane Fluctuations and ELMs (N.Nishino, L.Roquemore)

Summary of FY04 Boundary and Edge Experiments (cont)

- ELM's
  - ELM Characterization (R.Maingi)
- Fuelling Efficiency and Neutral Pressure
  - Initial Supersonic Gas Injection (V.Soukhanovskii)
- Particle Control
  - Development of Boronization on Hot Surfaces and Boronization Between Discharges (H.Kugel, R.Maingi)
  - Comparison of HeGDC and Helium Discharge Wall Conditioning (H.Kugel, R.Maingi)
  - *Initial Lithium Pellet Injection (H.Kugel)*

FY05 Run Time scheduling is a work in progress awaiting budget news on the final total Run Weeks

- NSTX FY05 Research Forum September 23-24, 2004 guidance was to plan for 14 Run Weeks
  - Total of 22 proposals requesting 21 days
  - Combined and reduced to 11 days (Project requested)

- Main Areas of the Approved Experimental Proposals
  - (1) ELMs/Pedestal
  - (2) Turbulence & Transport
  - (3) Divertor Physics
  - (4) Development Issues/Cross-cutting

FY05 Boundary Physics Approved Experimental Proposals

(1) ELMS/Pedestal

Forum 05 Boundary Physics Experiment Proposal	Days Requested	Topic	Priority
15) Maingi/ 16) Osborne	1	NSTX, DIII-D collaboration on edge pedestal comparison	1
19) Maingi (stabilty)/1) Boedo (dynamics)14)Kaye (stability part)	1	NSTX, ORNL, UCSD collaboration on ELM dynamics and classification, stability	1
20) Tritz	1	NSTX, JHU collaboration on ELM pulse propagation	1
13) Evans	1	NSTX, DIII-D collaboration on comparison of pedestal control	1
21) Ridha/Menard	1	ELM comparison studies, ASDEX-U, MAST, NSTX collaboration	2

Total: 4 days priority-1, 1 day priority-2

FY05 Boundary Physics Approved Experimental Proposals

(2) Transport and Turbulence

Forum 05 Boundary Physics Experiment Proposal	Days Requested	Topic	Priority
1)Boedo/4)Soukhanovskii	1	UCSD/DIII-D/LLNL collaboration on comparison of SAP plasmas, fundamental turbulence and transport	1
10)Bush/5) K. C. Lee	1	ORNL collaboration on L-H precursors and turbulence	1
6) Maqueda	1	Imaging of turbulence	2
11)Biewer	1	Flows role in L-H transition	2

Total: 2 days priority-1, 2 days priority-2

FY05 Boundary Physics Approved Experimental Proposals

(3) Conventional Divertor Physics

Forum 05 Boundary Physics Experiment Proposal	Days Requested	Topic	Priority
1) Scalings and Profiles(Boedo)/2) Maingi-Paul	1	UCSD-ORNL collaboration on Scalings and profiles, Power balance	1
3) Vlad/18) Pigarov	1	LLNL-UCSD collaboration Divertor regimes, basic divertor physics, atomic/molecular	1
22) Strachan	1/2	Divertor physics/fueling/detachment	1

Total: 2.5 days priority-1

FY05 Boundary Physics Approved Experimental Proposals

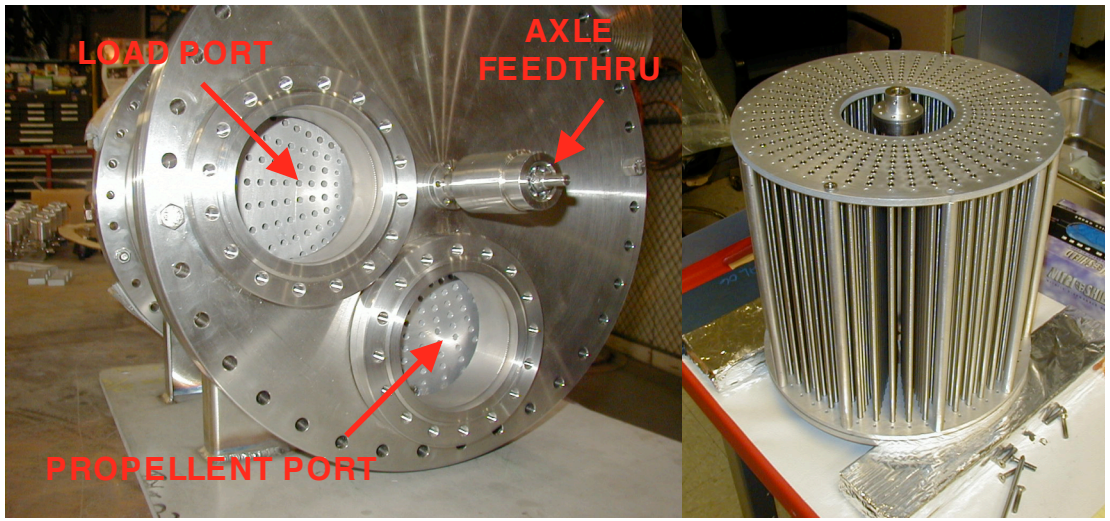
(4) Development/Cross cutting

Forum 05 Boundary Physics Experiment Proposal	Days Requested	Comments	Priority
7) Kugel	1	LPI characterization, recycling,edge control	1
8) Soukhanovski	1	LLNL collaboration on Supersonic Gas Injector	1
12) Raman (anti-CHI)/1) Boedo (Biasing)	1/2	UW-UCSD collaboration Boundary control, pumping, SOL control	1
17) Krashenninikov (piggyback)	0	Dust studies, code, modeling	1

Total: 2.5 days priority-1

Lithium Pellets Injected into NSTX Discharges

• 34 mg injected using 17 pellets, 2 mg ea, 100 m/s



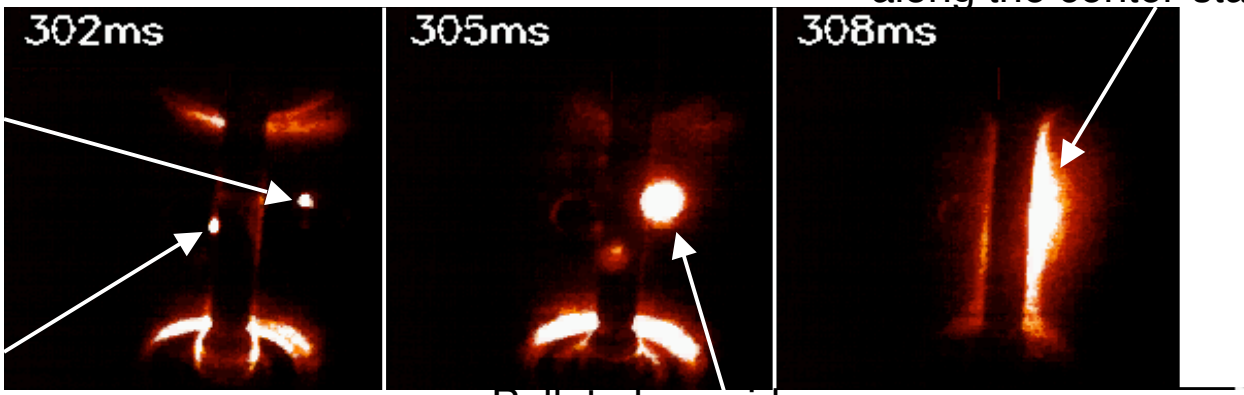
OUTBOARD VIEW

400 BARREL TURRET

- Cartridge style injector for injecting solid pellets (<1 – 5 mg) & powder (micro-pellets)
- 10 – 200 m/s radial injection
- 1 – 8 pellets per discharge
- 400 pellet capacity

Lithium vapor spreading along the center-stack

Lithium Pellet moving through plasma after entering boundary

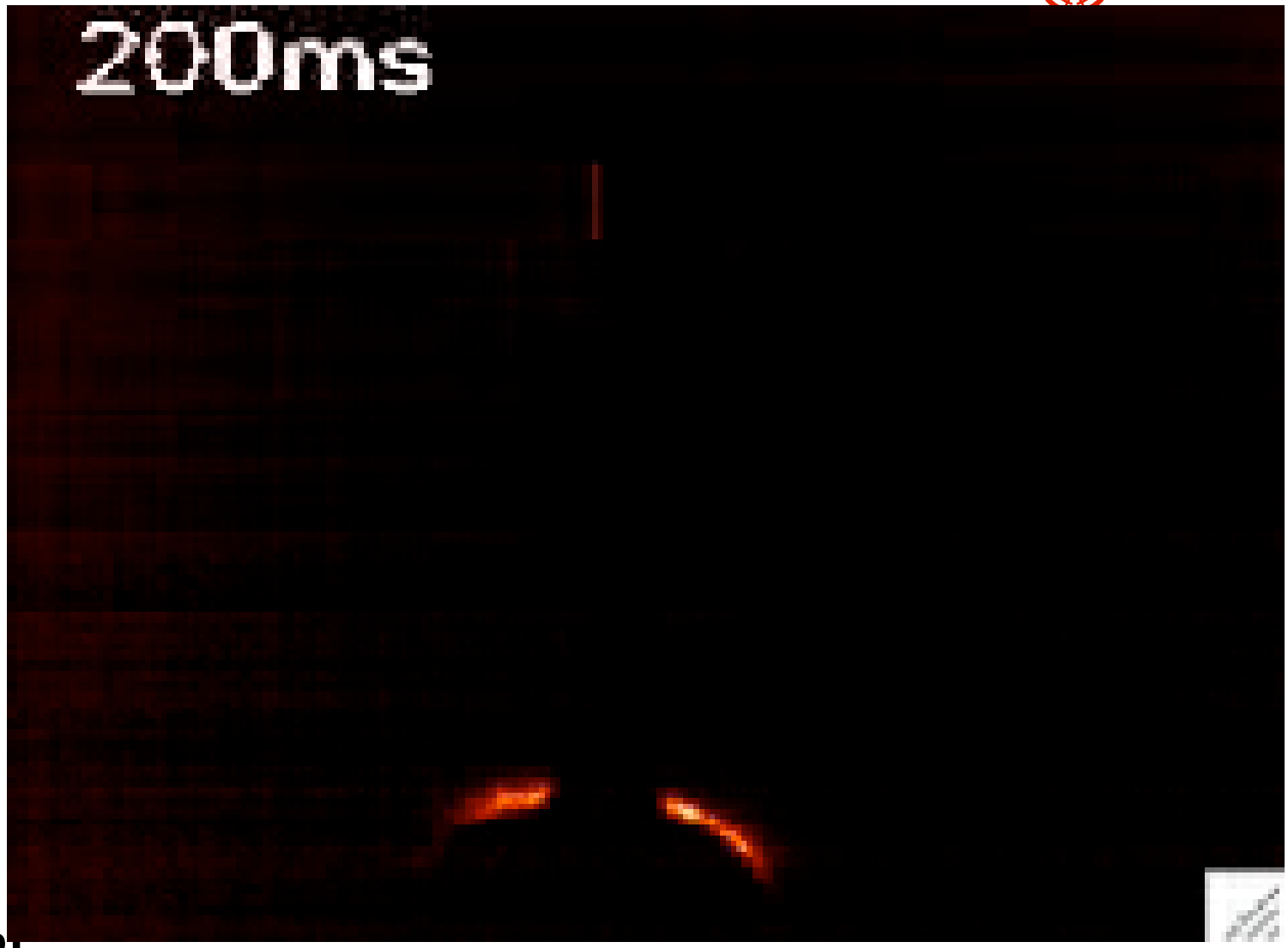


In-board gas injector

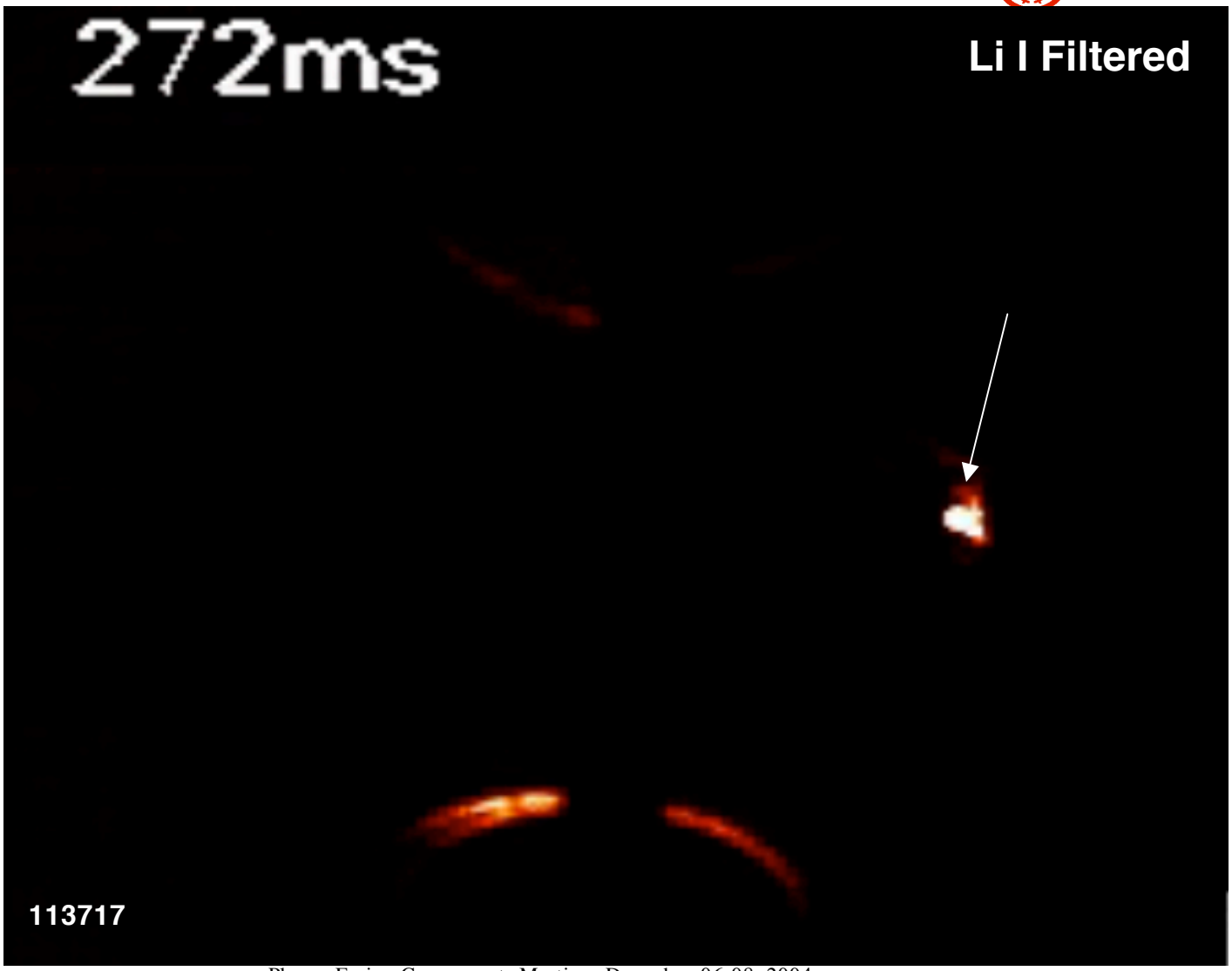
Pellet plasmoid approaches center-stack

Li I Plasma-TV -C.Bush, ORNL

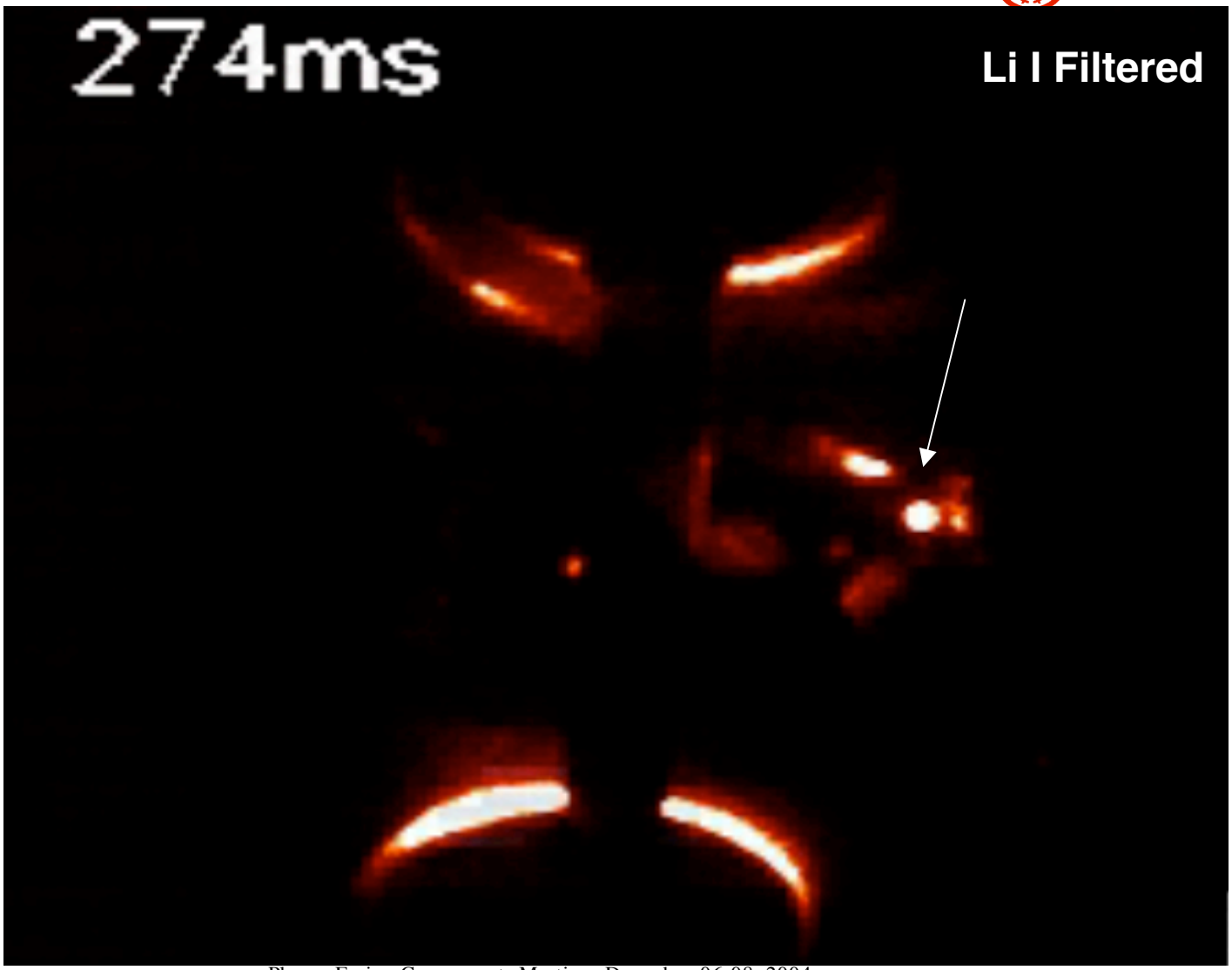
Movie of Lithium Pellet Injection into Ohmic Discharge



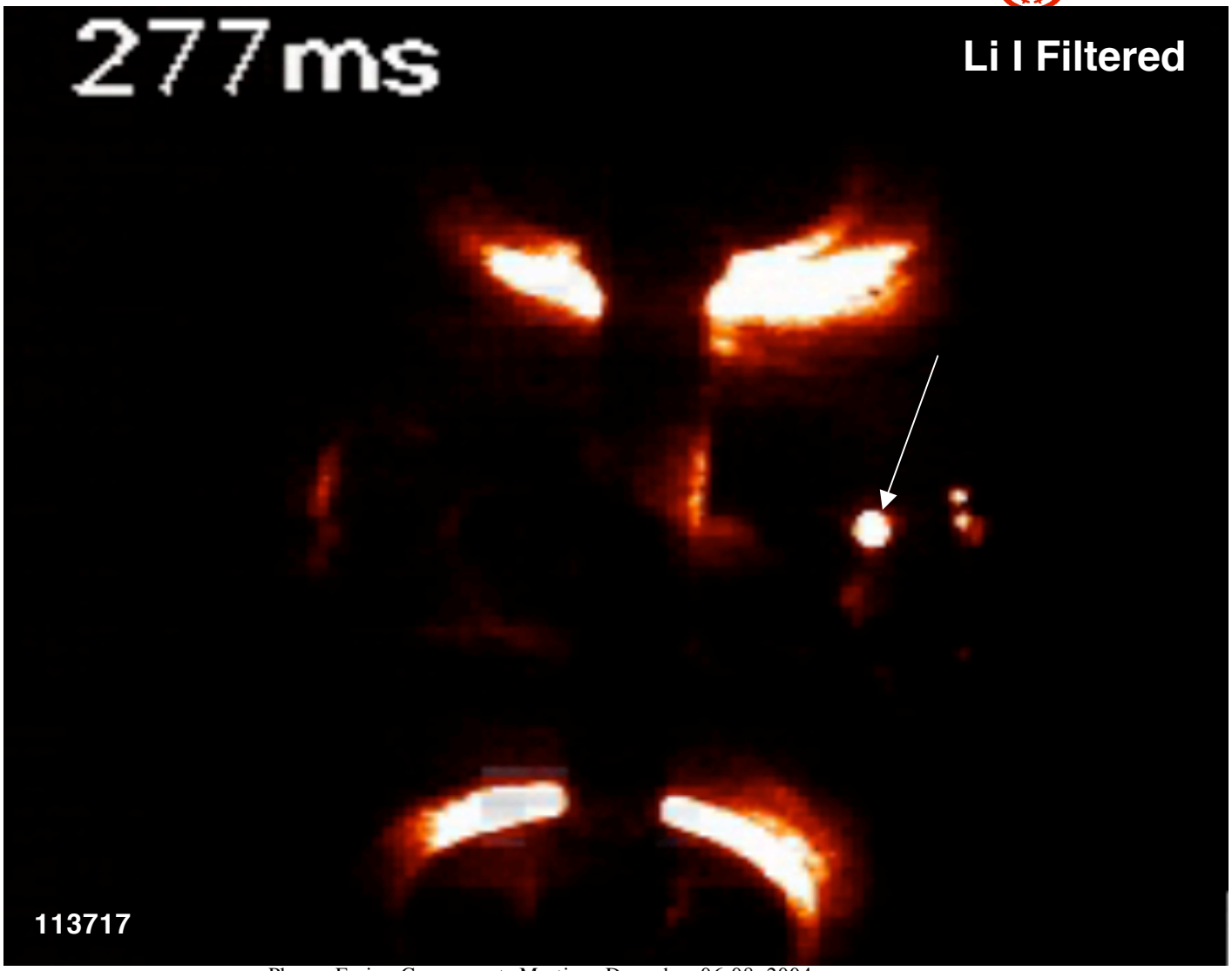
Lithium Pellet Injection Arrival at Edge of Ohmic LSN Discharge



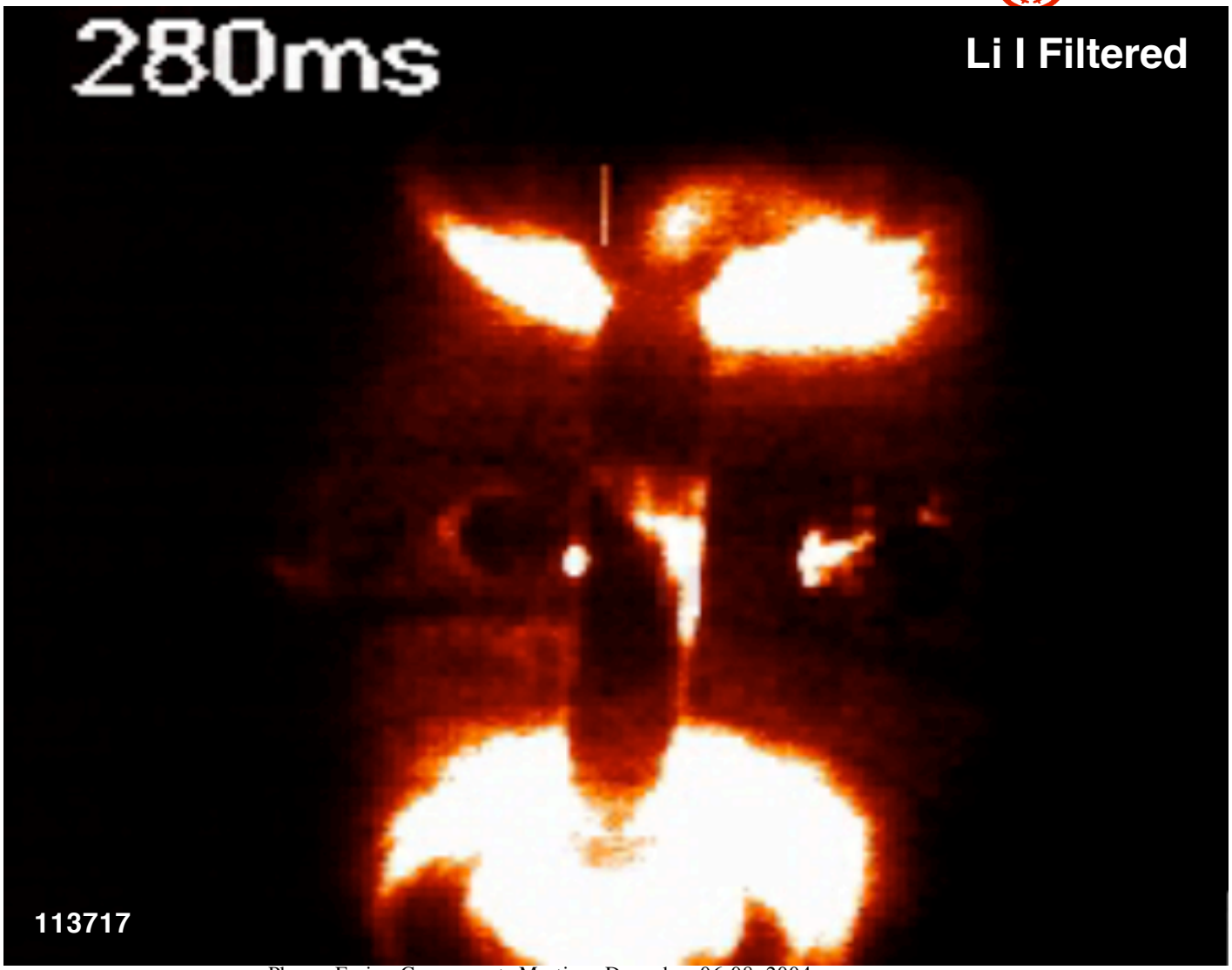
Lithium Pellet Ablating at Edge of Ohmic LSN Discharge



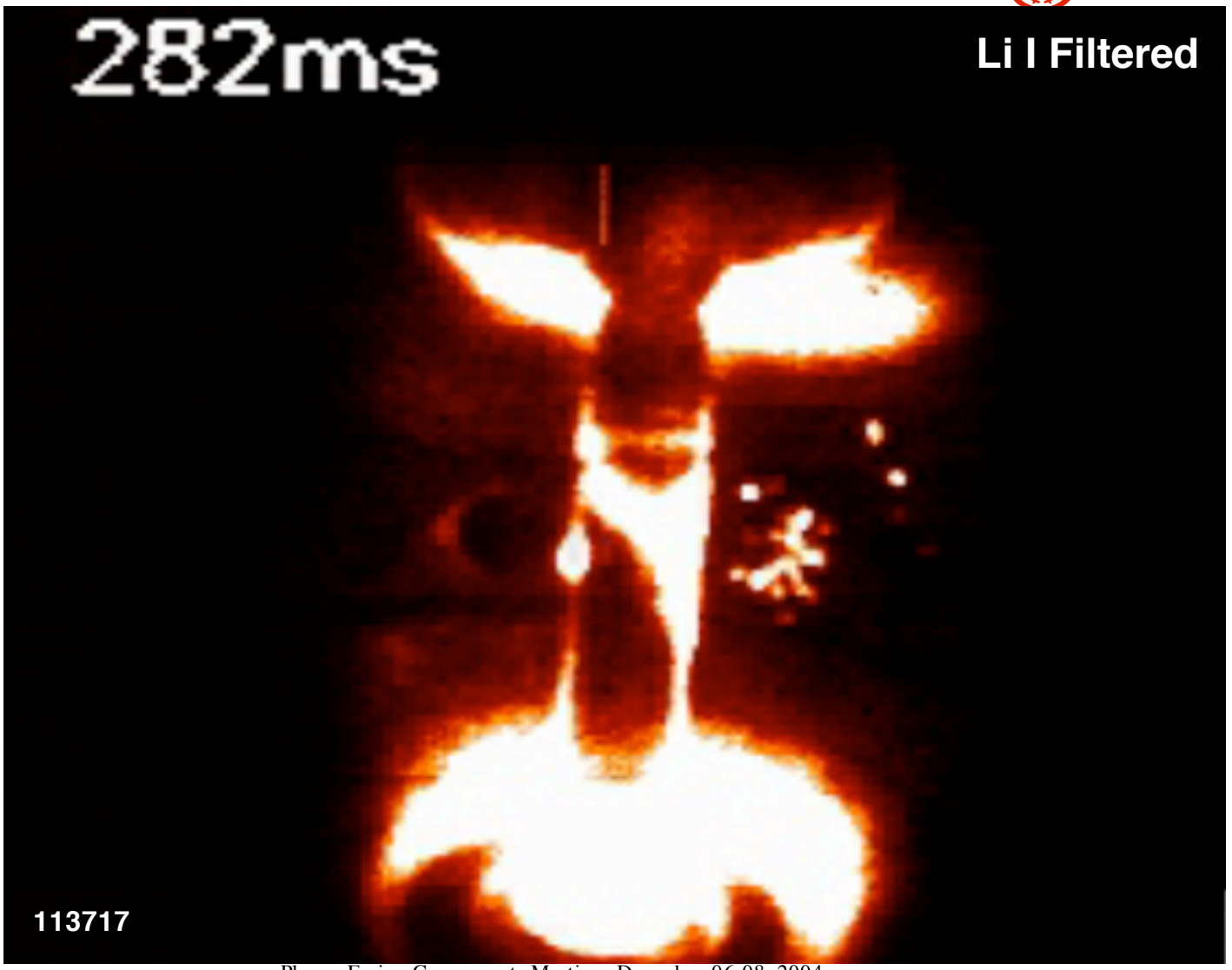
Lithium Pellet Traversing Ohmic LSN Discharge



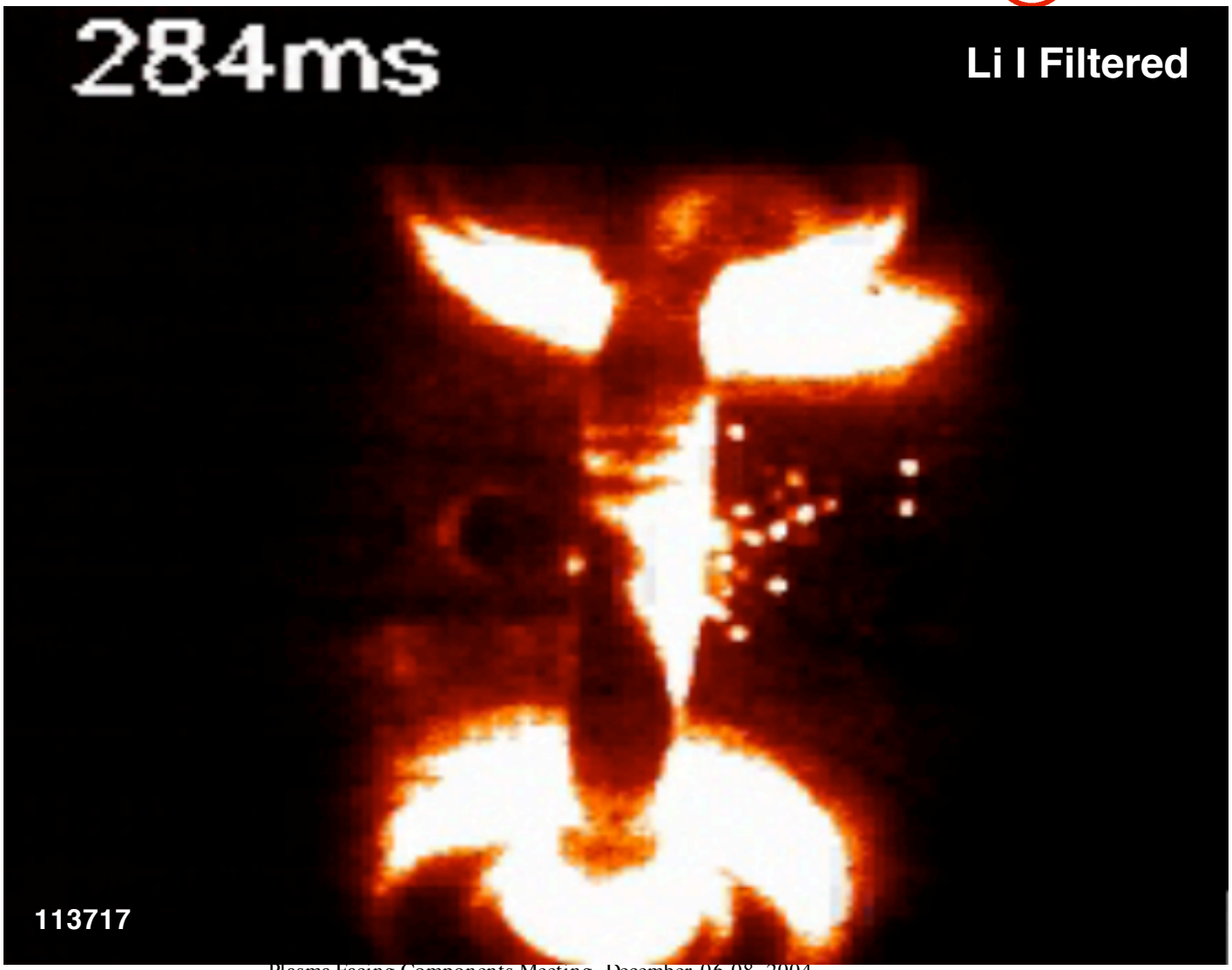
Lithium Reaching Center Stack and Divertors During Ohmic LSN Discharge



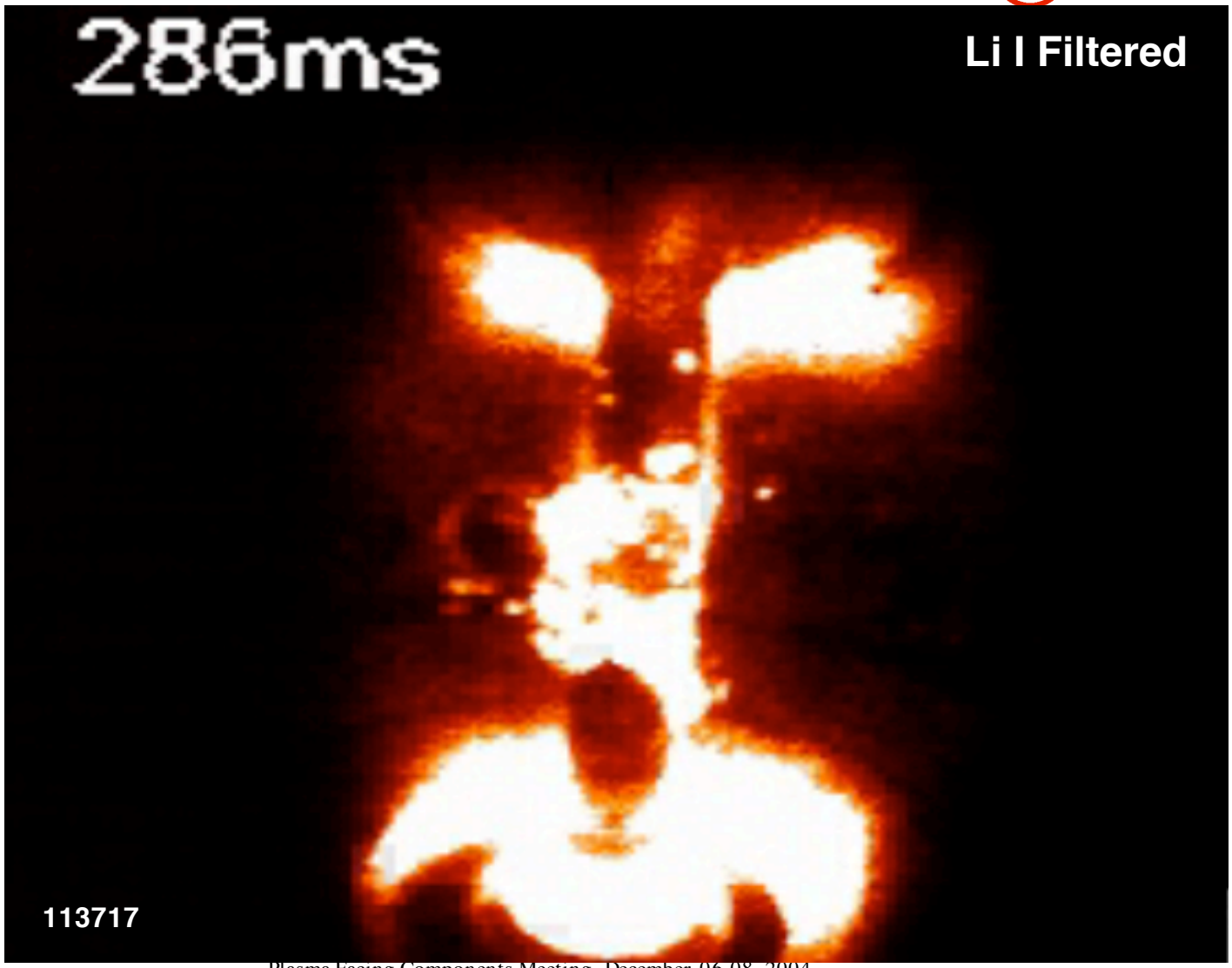
Lithium Deposited on Center Stack and Divertors During Ohmic LSN Discharge



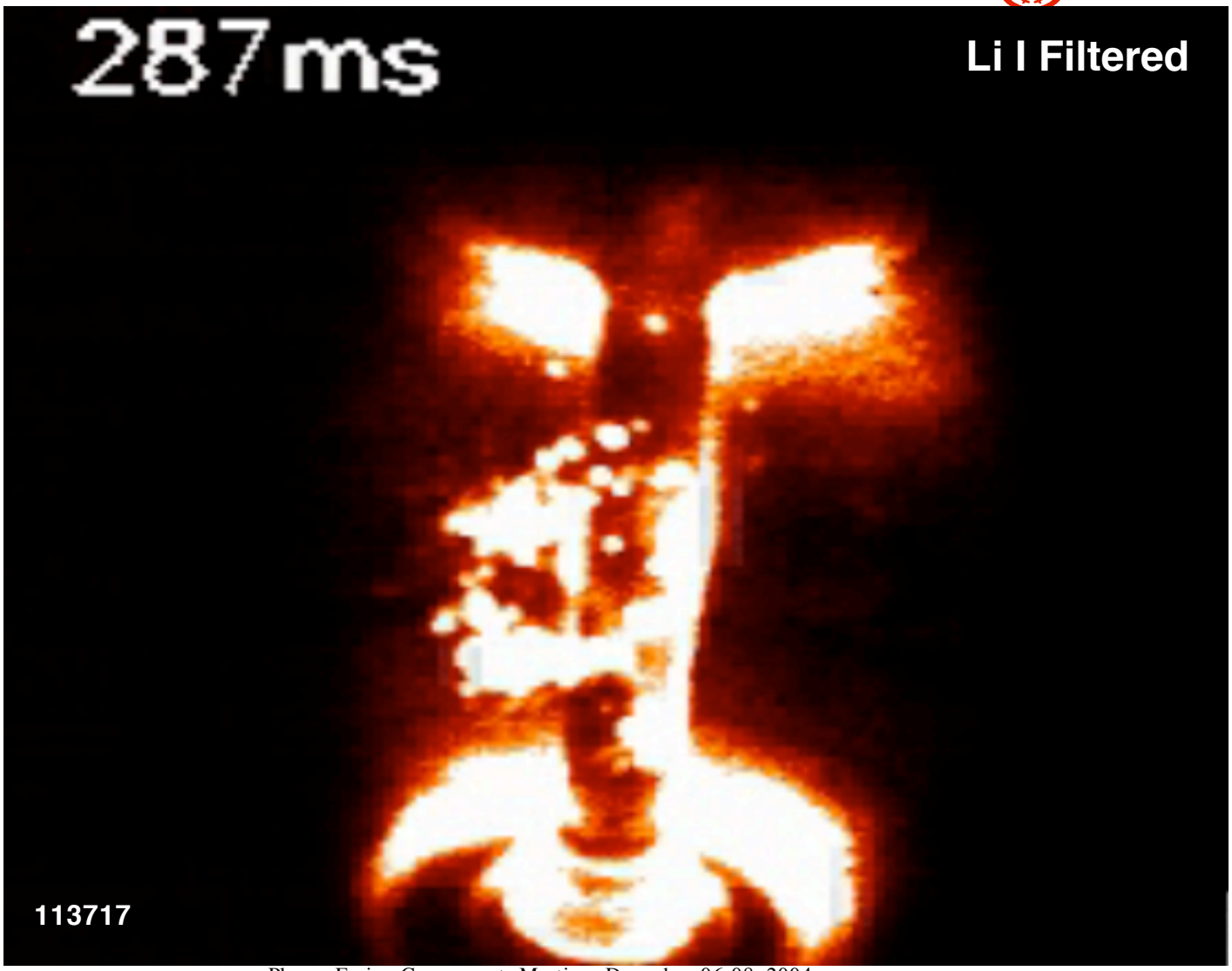
Significant Lithium Deposition on Center Stack and Divertors During Ohmic LSN Discharge



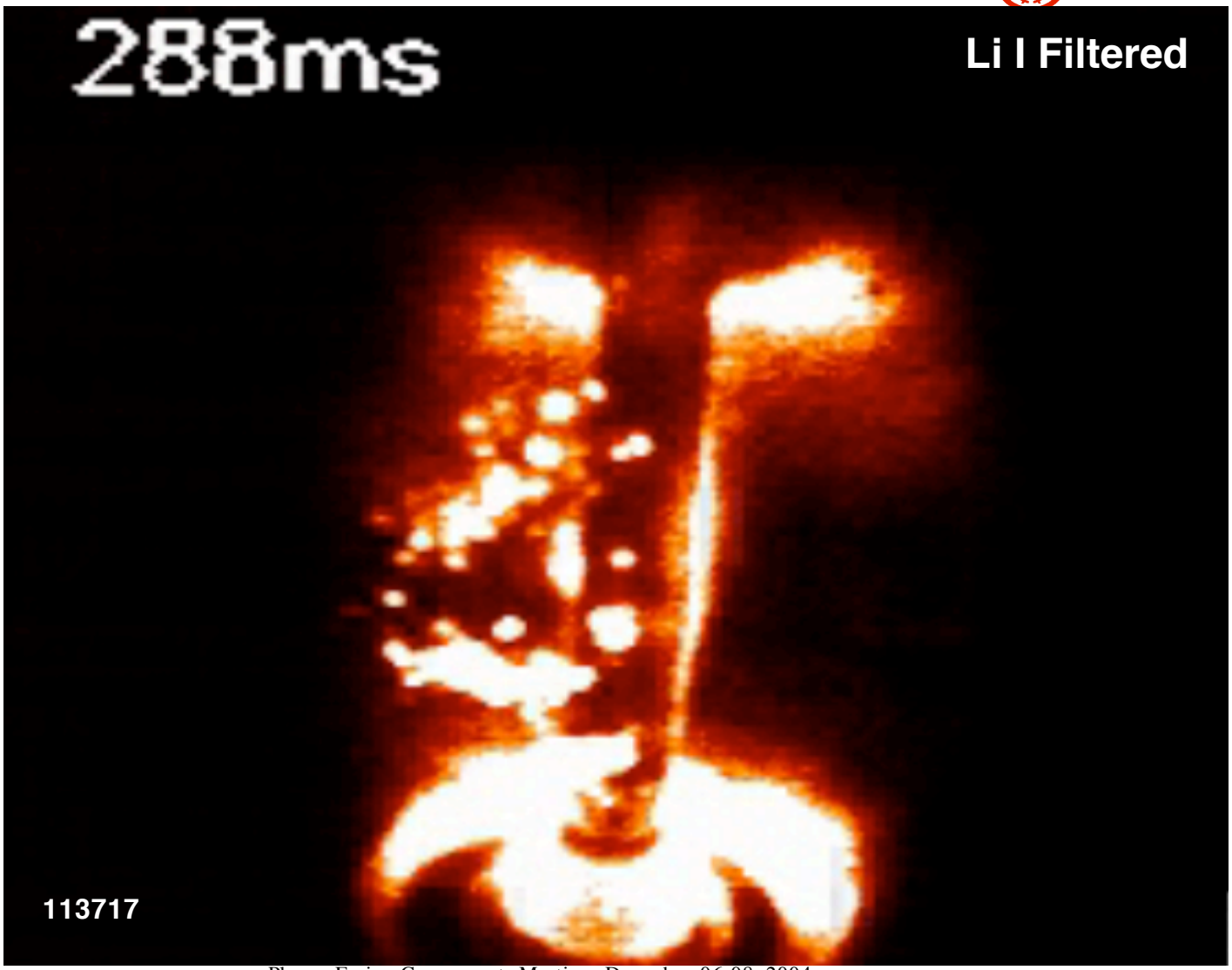
Continuing Lithium Deposition on Center Stack and Divertors During Ohmic LSN Discharge



Lithium Pellet Fragments Continuing Past Center Stack During Ohmic LSN Discharge



Final Stage of Li I Luminosity from Coated Regions and Pellet Fragments During Ohmic LSN Discharge



NSTX Experimental Plans in FY05 for Lithium Pellet Injection

1) Characterize Lithium Pellet Injection in NSTX

- Inject Li pellets (0.1-2 mg, 20-400 m/s)
- Probe NSTX edge transport barriers,flows, and rotation
- Measure
  - Pellet ablation along radial trajectory
  - Transport from midplane to core & divertor

2) Particle Control Using Lithium Wall Coatings via Pellet Injection

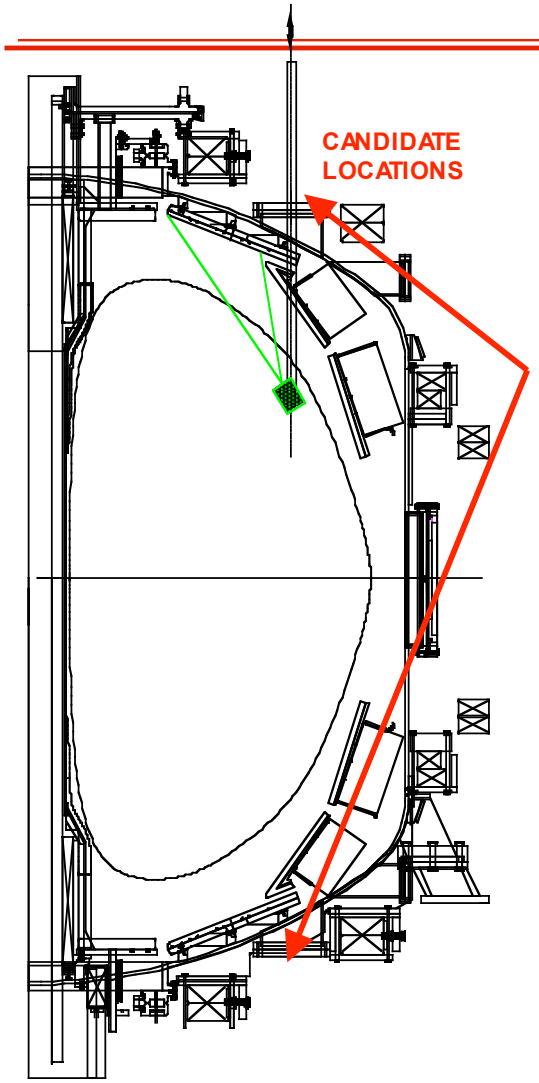
- Use results from the pellet characterization experiments to select the optimum discharge conditions and pellet deposition region
- *Measure: recycling, fueling efficiency, confinement, profiles,transport, neutron and power yields*

In Parallel with FY05 Lithium Pellet Injector Operations, Off-line Testing of Lithium Evaporators

- Prototype Lithium Resistive and E-beam Evaporators being tested off-line and CDX-U for FY06 Operation in NSTX.

- If possible, a candidate Evaporator will be tested in NSTX during FY05.

NSTX Module-A Lithium Evaporators Operational in FY06



- Goal: Control divertor recycling using between-shot application of lithium coatings (*best region for coating might be derived from LPI exps*)

- Is lithium-on-graphite acceptable? Or is metallic lithium on an impenetrable substrate needed?

- Install an insertable e-beam (or resistively heated) deposition system (upper & lower ports)

- Deposit few 1000 Å of lithium. Withdraw deposition system.
  - 1000 Å coating in 10's of sec
  - Cycle time is dominated by insertion/removal of deposition source.
- Coat before every shot
- 1000 shots ⇒ 0.1 mm accumulation
- Accumulation limited by intercalation,erosion, & evaporation.

Specifications for Module-A Lithium Evaporators

1. Evaporator shall be insertable on a divertor port probe.
2. Probe shall operate at 22° to vertical and fit on 8 inch gate valve.
3. Probe shall be insertable up to 48 inches into the vessel.
4. Probe shall be less than 4 inches wide and pass through divertor tile gap.
5. Probe shall be insertable to the operating region in 1 min.
6. Operation shall not exhibit significant out-gassing in NSTX vacuum.
7. Operation shall not involve environmental, health, and safety risks.
8. Deposition shall be aimed at divertor or other TBD surfaces.
9. Deposition time shall be less than 10 min.
10. Deposition thickness shall be at least 1000 Å over the desired region.
11. After operation, probe temperature shall allow withdrawal in 1 min.
12. Probe design shall allow convenient lithium reloading.
13. Probe operation shall be relatively maintenance free during annual operations.
14. Probe controls shall be automated wherever possible.

Requested Near Term R&D Support for NSTX Lithium Operation

- Assist with the development of an evaporative coating system for CDX and NSTX tests.

- Test evaporator systems on CDX-U in early FY05.

- Characterize lithium deposition on graphite, with and without plasma interaction.

Summary and Conclusions

- NSTX is enthusiastic about its lithium plan.
- According to plan, Lithium Pellet Injection was initiated in FY04.
- FY05 Lithium Pellet Injection experiments will characterize initial lithium coatings and pellet behavior in ST's.
- In FY06, between-shot lithium evaporators will be used to deposit thicker lithium coatings on recycling surfaces.
- NSTX needs near term support (1)to facilitate analysis of the planned FY05 lithium pellet experiments, (2) development, design, and planning for the installation of the evaporators, and (3)analysis of lithium film behavior.
- We look forward to hearing about what was learned during the past year of effort.